Some Energy-Saving Measures for Commercial Buildings

Projects supported in part
by the Alberta/Canada
Energy Resources
Research Fund

1989
Edmonton

Alberta
ENERGY
Scientific and Engineering
Services and Research Division

ISBN 0-86499-588-1

Pub. No. I/263

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Foreword

Since 1976, numerous projects have been initiated in Alberta by industry and by academic research institutions which are aimed at better utilization of Alberta's energy resources.

These research, development and demonstration efforts were funded by the Alberta/Canada Energy Resources Research Fund (A/CERRF), which was established as a result of the 1974 agreement on oil prices between the federal government and the producing provinces.

Responsibility for applying and administering the fund rests with the A/CERRF Committee, made up of senior Alberta and federal government officials.

A/CERRF program priorities have focused on coal, energy conservation and renewable energy and conventional energy resources. Administration for the program is provided by staff within the Scientific and Engineering Services and Research Division of Alberta Energy.

In order to make research results available to industry and others who can use the information, highlights of studies are reported in a series of technology transfer booklets. For more information about other publications in the series, please refer to page nine.

Some Energy-Saving Measures for Commercial Buildings

Since 1983, 13 research projects concerning energy conservation in commercial buildings were funded in part by the Alberta/Canada Energy Resources Research Fund (A/CERRF). Nine projects were described earlier in four technology transfer publications.* The remaining four projects are summarized here.

* *Energy Management in Commercial Buildings*, 8 pages, December 1986.
Control of Heat Loss Associated with Overhead Doors, 6 pages, January 1987.
Some Methods of Saving Energy with Fluorescent Lighting, 8 pages, March 1988.
A Programmable Controller for Parking Lot Block Heaters, 9 pages, March 1988.

See page nine for availability of these publications.

Retrofit Measures for Commercial Buildings

Few studies have been made of the effects of retrofitting or air sealing on energy consumption in commercial buildings, especially in multi-use office towers having rental areas greater than 2 800 m^2 (30 000 sq. ft.). However, in some British, American and Scandinavian studies, it appears that air sealing can reduce heating costs by 10 to 20 per cent, and retrofitting can produce energy savings averaging 22 per cent. In an attempt to determine how these claims relate to commercial buildings in Alberta, a study was initiated in 1985/86 by Adept Engineering, a division of RTM Engineering Ltd. of Calgary (now known as RTM Engineering Ltd.).

In surveying published results from the above studies, RTM investigators found that air leakage accounted for 20 to 46 per cent of the heat loss in multi-storey office buildings. Also, retrofits of these types of buildings showed the following:

- weatherstripping and caulking can reduce air leakage around doors and windows by half;
- caulking at wall-to-wall, wall-to-roof and wall-to-ceiling joints is cost-effective;
- dampers in air-handling systems are a major source of leakage; and
- thermography is a cost-effective method for identifying air leakage through the envelopes of commercial and industrial buildings.

With this information, RTM Engineering began a study involving three identical office towers in Calgary. It was decided that one tower would be used as a control, another would undergo air sealing and, in the third, several types of retrofits would be made.

In the air-sealing portion of the investigation, thermographic scans and visual inspections of the selected building were proposed. The air leakage would then be determined by using the mechanical system to pressurize the building. The data from air leakage measurements, and information about the characteristics of the building itself, would be used to calculate the potential energy savings arising from insulating and tightening the building envelope. Assuming the potential savings were found to be attractive, the building would be sealed, and energy consumption would be monitored to permit comparison of energy use before and after sealing.

From a review of existing retrofit technology applicable to commercial office towers, it was recommended that an evaluation should be made of the following retrofit measures in one of the test buildings:

energy-efficient, variable-speed motors;

lighting control;

low-leakage dampers to control the entry of all cold air through rooftop heating and cooling systems;

more efficient operation of boilers;

power factor correction;

temperature set-back control;

natural cooling to supplement mechanical cooling under certain conditions;

using waste heat to preheat combustion air; and

control of the electricity supplied to parking lot electrical receptacles.

In the research plan devised by RTM Engineering, selected retrofit measures would be evaluated individually for one month to determine the effects of each on energy consumption. They would then be implemented simultaneously to obtain an overall effect on energy savings. Before the plan could be initiated, however, the buildings were sold. Because the new owners did not wish to proceed with the project, RTM Engineering attempted to continue the project in alternative test buildings.

The Relax Inn Group of Companies indicated an interest in the various energy-saving measures proposed by RTM Engineering, but did not wish to become involved in a lengthy research program. Instead, RTM was asked to introduce all of the proposed retrofit measures at a Relax Inn hotel in Calgary to achieve maximum benefits in a short time.

During the following winter (1986/87), Alberta experienced unusually warm weather, making it difficult to realize the full benefit of the various retrofits. Nevertheless, the Relax Inn Group of Companies subsequently proceeded to design retrofit schemes for 15 Relax Inns coast-to-coast and involved RTM Engineering in the project through a third-party financing scheme.

The potential cost savings from the retrofitting and sealing of commercial buildings are substantial. RTM Engineering estimated that $11 million a year could be saved (assuming energy savings of 20 per cent) if all 238 office buildings in Calgary that are larger than 2 800 m^2 (30 000 sq. ft.) were retrofitted and sealed.

Air Flow Rate for Various Types of Buildings and Construction Methods

Building Construction Type	Flow Rate L/sec-m^2 @ 50 Pa
Tight/Multi-storey Office Building	0.38
Average/Multi-storey Office Building	1.144
Loose/Multi-storey Office Building	2.289
Shopping Centres	4.5 15.2
Schools	3.8 8.9
Commercial/ Industrial	0.46 to 1.80 0.83 1.67 2.19
Apartments	1.90
Residential	
- Low Energy	0.77
- Conventional	1.90
Wall Construction	
- concrete tile, insulation tile, plaster	1.88
- concrete, insulation	1.47
- steel, insulation	1.22
- concrete, insulation block, plaster	0.97
- plain brick	1.57
- plaster, brick	0.012
- metal, glass curtain wall	0.24

(Source: *Phase I Report on Comprehensive Retrofit Measures in Commercial Buildings*, RTM Engineering, July 8, 1986)

Computerized Building Design and Energy Analysis

More often than not these days, entire buildings, or their mechanical, electrical, heating and ventilation subsystems, are designed with the aid of computers and appropriate software. In fact, designers can choose from such a wide variety of software, that it is sometimes difficult to determine which is most suitable for a particular task.

Consequently, in 1984/85, Vinto Engineering Ltd. (now known as Hemisphere Engineering Inc.) of Edmonton received financial support from A/CERRF to review and prepare an inventory of relevant computer software available at the time. The resulting inventory included 67 building-design programs and 41 programs suitable for analysing the energy performance of buildings. The software covered a broad spectrum of circumstances, ranging from designs for small homes to those for large commercial buildings.

The inventory report identified specific uses for each program and included information regarding source, availability, required computer equipment and program language.

Before energy-analysis programs can be used to make predictions about the energy consumption of a structure, it is necessary to input climatic data for the geographical area in which the building is located. Therefore, Hemisphere Engineering also developed an Alberta weather data base comprising climatic information for eight regions of the province. They are: Calgary, Edmonton, Edson, Fort McMurray, Grande Prairie, Lethbridge, Medicine Hat and Red Deer.

The compiled weather data can be used in sophisticated energy analysis programs requiring mainframe computers, or in less-complex programs designed for microcomputers.

Two sophisticated programs for office buildings (APEC ESP II and Meriwether ESA) were tested with weather data and compared with the use of a less-complicated office building program (Carrier OPCOST). Similarly, comparisons were made between two typical programs (HOTCAN and Carrier OPCOST) used for predicting energy consumption in individual homes.

Energy consumption values, calculated by the two sophisticated office building programs for each climatic region, agreed with each other within ± 5 per cent. They also agreed with results from the less-complex OPCOST program. However, there was somewhat less agreement between the values for home heating requirements predicted by HOTCAN and Carrier OPCOST (ranging from a difference of 2.5 to 15.6 per cent).

The Hemisophere inventory provides designers, consultants, builders and contractors with the information needed to obtain and use computerized energy-analysis or building-design programs for Alberta's climate. Both the program inventory and the weather data base are available from Hemisphere Engineering at a nominal cost.

A Ventilation Control System Based on Carbon Dioxide Levels

The volume of fresh air supplied by the heating, ventilation and air-conditioning (HVAC) systems of most buildings is usually based on (1) the maximum number of people expected to occupy the building and (2) a specified per person ventilation rate. Because the number of people in a building at any time seldom reaches the maximum for which the HVAC system was designed, and the number of occupants varies continuously, more air is supplied and conditioned than is required. This represents unnecessary energy consumption.

In 1983, Cheriton Engineering Inc. proposed a method for controlling the amount of incoming air by using a sensor/controller which responds to indoor carbon dioxide levels. This was based on an earlier report by the University of California which stressed that carbon dioxide concentration is the most important characteristic of indoor air and should be used in ventilation control schemes. In Cheriton's proposal, a carbon dioxide sensor/controller would be used to control the air dampers of a building's main ventilation and air-conditioning system.

Subsequently, A/CERRF funded a predesign study of the J.J. Bowlen Building in Calgary. Particular emphasis was placed on the area used by the Alberta Government's Land Titles section because the number of people who require services from this agency fluctuates daily.

It was learned that a separate air-conditioning and ventilation system serves the two-floor area occupied by the Land Titles group. It was also discovered that the main air cooling coils in the building had been modified to provide "free cooling" to the chilled water system when the outdoor temperature was below a certain level. This meant that large quantities of outside air were brought inside for water chilling. This was done to save energy, but it directly conflicted with the proposed carbon dioxide control technique, which was intended to minimize the intake of outside air. Therefore, to conduct the test properly, the free cooling process would have to be suspended.

The investigation also revealed that even if the carbon dioxide control system were installed, the payback period in terms of reduced energy costs would be in excess of five years. This, combined with the loss of free cooling benefits, caused the building owners to withdraw from the project. Although this led to termination of the project, it was concluded that carbon dioxide control could be practical in hotel lounges or restaurants which experience large changes in the number of occupants. As long as these facilities have independent ventilation systems, and installation of a carbon dioxide controller can be accomplished with few modifications to the air-handling system, there is some merit in at least investigating the concept.

Energy Savings Through Direct Evaporative Cooling

In most commercial buildings throughout Canada, a comfortable indoor environment is achieved and maintained by central air-conditioning systems, which use chillers to lower the temperature of incoming air during summer months. These chillers, however, consume substantial amounts of energy over a typical cooling season.

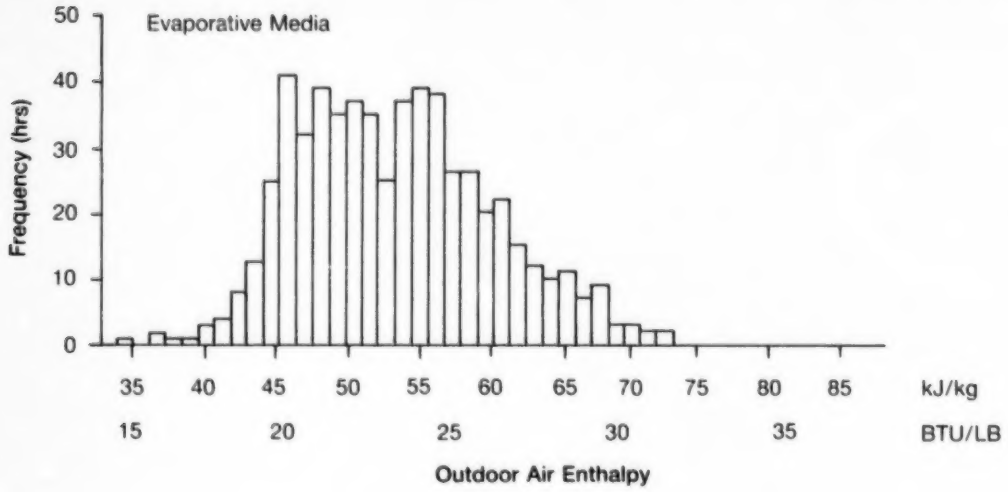
To determine whether some of this energy could be saved, a study was initiated at the University of Lethbridge, by Safronek Pomeroy & Associates Ltd. of Calgary, to assess direct evaporative cooling as an alternative to the use of chillers. This required an air-conditioning system equipped with evaporative humidification units, which are normally used to supply humidified air during cold weather. However, if such units are capable of using 100 per cent outdoor air, they can be used during the summer for direct evaporative cooling. This refers to the heat transfer process occurring when air is passed over an unheated water surface. The result is a drop in air temperature and a rise in relative humidity. This makes people feel cooler, even though the heat content of the air remains unchanged.

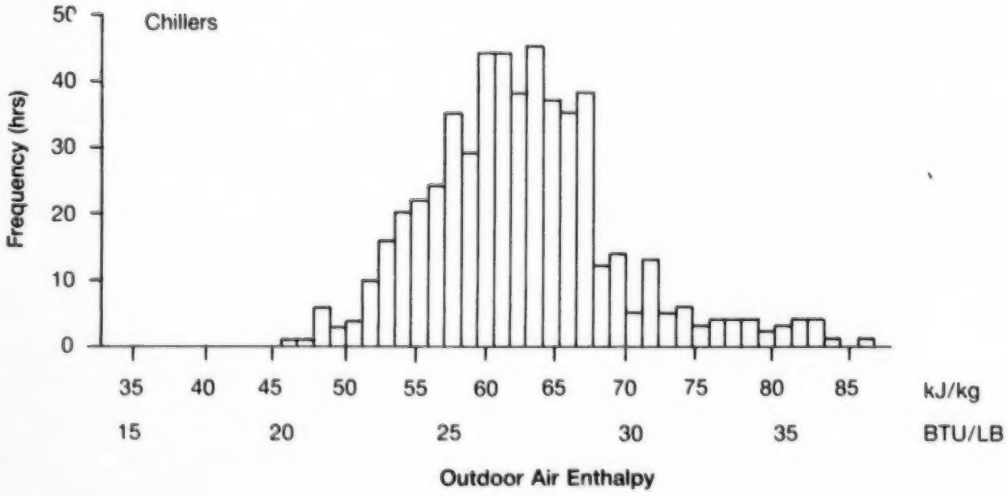
The cooling effect is achieved by the use of devices known as spray coils, cellulose media or glass fibre media, which permit contact between water and a moving volume of air.

In the University of Lethbridge study, several air-handling systems and the central refrigeration system serving University Hall and the Performing Arts Centre were monitored for temperature, humidity and operational time from May 1 to October 31, 1987. This represented a typical cooling season. Altogether, nearly 100 monitoring points were used. Data pertaining to the air-handling systems were recorded hourly by a Honeywell Delta 5200 building management control system, whereas data for the chillers were recorded manually. The enthalpy, or heat content, of outdoor air and the degree of indoor cooling were used as the principal criteria in determining whether chillers or evaporative humidifiers would be used. Records were kept of the time that each system was operated. This allowed the investigators to calculate the value of unconsumed electrical energy resulting from the use of evaporative humidifiers instead of chillers.

It was found that the evaporative humidifiers were operated for approximately 38 per cent of the total operational time for the test period. This reduced the operational time of the chillers by 588 hours, which represented cost savings of $12 400. For the particular wet cellulose and spray coil units used in the University of Lethbridge system, those cost savings amounted to payback periods of five years and six years, respectively. For buildings experiencing less energy efficiency than those at the University of Lethbridge, shorter payback periods can be expected. On the other hand, if evaporative humidifiers were retrofitted to an existing air-conditioning system, the payback period likely would be 10 to 12 years.

Most Suitable Outside Air Conditions for Evaporative Media vs. Chillers





(Source: *Demonstration of Evaporative Cooling Utilizing Building Humidification Systems*, Saltonek Pomeroy & Associates Ltd., August 1988)

In assessing the limitations of the concept, Safronek Pomeroy & Associates noted that direct evaporative cooling is not recommended for air-handling systems capable of introducing only a fixed percentage of outdoor air into buildings. The benefits of direct evaporative cooling are not as significant in air-water systems (induction or fan-coil), where the main building systems rely on liquids (such as water or glycol) to remove most of the heat from occupied spaces. Similarly, direct evaporative cooling is not suitable for buildings that require close control of temperature or humidity.

Examples of air-handling systems which are suitable include: constant air volume with reheat; variable air volume (with or without terminal reheat); dual duct; and multi-zone.

The outdoor air enthalpy also places some limitations on the use of evaporative humidifiers for purposes of cooling. During the University of Lethbridge study, for example, it was found that cooling requirements could be satisfied with evaporative media when the outdoor air enthalpy was between 45 kJ/kg (19 BTU/lb) and 60 kJ/kg (26 BTU/lb). These values corresponded to temperature and relative humidity conditions of 15°C (60°F) and 40 per cent relative humidity, and 24°C (75°F) and 45 per cent relative humidity, respectively.

It was also found that the spray coil units produced a higher saturation efficiency (85-100 per cent) than did the wetted media units (70-90 per cent). Efficiency increased as the air stream velocity across the units was increased.

To determine whether the use of evaporative humidifiers would represent a health concern, the investigators routinely measured the bacterial content of water in the evaporation section sumps. They used Easicult-TTC slides dipped in water, followed by a 48-hour incubation period. It was found that bacteria counts were within safe limits, apparently because the water temperature was low and biocides had been used as a precaution.

It was concluded that within the limitations already described, the use of direct evaporative cooling should be considered for commercial buildings throughout southern Alberta.

Contacts

For more information about retrofit measures for commercial buildings, contact:

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Telephone: (403) 253-4465

Persons wishing to obtain the inventory of building-design software and/or the Alberta weather data base, should contact the following:

R. Campbell
Hemisphere Engineering Inc.
10950 - 119 Street
Edmonton, Alberta
T5H 3P5

Telephone: (403) 452-1800

and ask for:

Report on Inventory of Computer Programs, Vinto Engineering, December 1984.

Report on Development of An Alberta Weather Input Data Base, Vinto Engineering, February 1985.

Additional details regarding carbon dioxide-based controllers for ventilation systems can be obtained from:

M.H. Siddiqui
Cheriton Engineering Inc.
Suite 500
10160 - 112 Street
Edmonton, Alberta
T5K 2L6

Telephone: (403) 421-4440

More information regarding evaporative cooling is available from:

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Additional copies of this publication are available from:

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Other publications in this series which are available and deal with energy conservation include:

A Practical Method for Defouling Heat Exchangers,
6 pages, March 1986.

Energy Management in Commercial Buildings,
8 pages, December 1986.

Control of Heat Loss Associated with Overhead Doors,
6 pages, January 1987.

Practical Methods to Seal and Insulate Residential Buildings,
9 pages, March 1987.

Energy-Conserving Characteristics of Common Building Materials and Methods,
14 pages, April 1987.

Performance Characteristics of Energy-Efficient Residential Furnaces,
9 pages, April 1987.

Some Methods of Insulating Basements, Walls and Windows,
10 pages, July 1987.

A Programmable Controller for Parking Lot Block Heaters,
9 pages, March 1988.

Some Methods of Saving Energy with Fluorescent Lighting,
8 pages, March 1988.

Methods for the Recovery and Reuse of Waste Heat in Some Commercial Operations,
9 pages, August 1988.

Some Energy-Conserving Concepts for Residential Buildings,
14 pages, November 1988.